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Survey of Laboratory-Acquired Infections*†

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WITHIN recent years attention has been drawn to the possibility of acquiring infection in the laboratory as a result of contact with various disease-producing agents. In 1941 Meyer and Eddie[1] reported 74 laboratory infections due to *Brucella*, much of their information being obtained from a questionnaire mailed to various laboratories in the United States. More recently Sulkin and Pike[2] summarized 222 laboratory infections due to viruses; they included cases reported to them in personal communications as well as published reports. Since the magnitude of the problem of laboratory-acquired infections could not be determined from the literature alone, it was suggested that the authors undertake a survey of laboratories in the United States for the purpose of disclosing unreported infections resulting from laboratory work. Data were collected by means of a questionnaire submitted to approximately 5,000 laboratories, including those associated with state and local health departments, accredited hospitals, private clinics, schools of medicine and veterinary science, undergraduate teaching institutions, biologic manufacturers, and various governmental agencies. This report is based not only on information received in reply to the questionnaire, but also upon cases reported in the literature.

The response to the questionnaire was in general gratifying. Replies were received to slightly more than half the questionnaires mailed.‡ An effort was made to circularize a questionnaire ** which, although brief and uncomplicated, would provide specific information perti-

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nent to a survey of this kind. In addition to obtaining information concerning instances of laboratory infections, data were requested regarding the number of persons engaged in laboratory work in an attempt to estimate the population exposed to risk. Information furnished concerning the latter point has provided only a rough estimate of this population; the problem of changing personnel imposed a serious limitation on the completeness of the survey. Again, in several instances, data regarding laboratory personnel and infections which had occurred prior to a changing administration were not available and hence could not be included in this report.

Since many laboratories do not keep records of instances of laboratory infection, much information was given from memory and some was only hearsay. Information derived from the latter source could not be included in the tabulations. Some commercial laboratories were unable to provide information because of a company policy not to release such data, while a few freely provided the data requested. These facts indicate that the number of cases reported here is a gross underestimate of those which have actually occurred.

Table 1 is a summary of all the laboratory infections occurring in the United States which have come to our attention, either through the survey or in published reports. In this and subsequent tables the infections are separated into 5 categories: bacterial, viral, rickettsial, parasitic, and those caused by fungi. A total of 1,342 infections, of which 467 have been published, have come to our attention.* Thirty-nine of the infections resulted in deaths, a case fatality rate of about 3.0 per cent. The highest proportion of deaths was among the viral diseases with a case fatality rate of 4.5 per cent as compared with 2.5, 3.0, 0.0, and 3.2 per cent in bacterial, rickettsial, parasitic, and fungus infections, respectively. Complications occurred in 59 or 4.7 per cent of the non-fatal infections.

In many instances it is impossible to state definitely that the infection was acquired in the laboratory. Consequently, an attempt was made to classify all infections as *definite, probable,* or *possible* with respect to their origin in the laboratory. This classification was based on the opinion of the person reporting the case, if given; otherwise it was based upon the circumstances and the nature of the infection. For example, except in those cases of cutaneous tuberculosis traceable to autopsy accidents, very few of the tuberculous infections could be classified as having been definitely acquired in the laboratory. On the other hand, infection with the virus of louping ill could presumably be acquired in this country only in the laboratory. Individual judgment is of necessity an important element in making this classification. Arbitrarily, we chose to consider as laboratory-acquired infections those resulting from laboratory work, whether occurring in a laboratory worker or in another person who happened to be exposed as a result of work with infectious agents. Infections resulting from field work involving the collection of material for laboratory study are included in the tabulations, but those which appeared to result from contact with patients on hospital wards have been excluded. For example, cases of Q fever in laundry workers handling laundry contaminated in the laboratory and relapsing fever acquired while collecting ticks for laboratory examinations were included, but those accidentally acquired outside the laboratory such as the cases of encephalitis and equine infectious anemia among veterinarians and a case of chickenpox in a laboratory technician resulting from contact with a patient in

* The majority of these cases (1,275) occurred since 1930.

the hospital were not considered to be laboratory infections. A number of cases of infectious mononucleosis were reported to us as laboratory infections; since the agent is unknown, and since these infections appeared to result either from contact with hospital patients or contact with other laboratory personnel, they were not considered to be laboratory infections.

In Table 1 the number of cases in each category in which there was reason to question the diagnosis is indicated in parentheses. Unless the person reporting the infection indicated that the diagnosis was indefinite, we could find no reason in most instances to question the diagnosis.

The members of the *Brucella* group of microörganisms far outnumber all other agents as causes of laboratory infections. Brucellosis, tuberculosis, tularemia, typhoid fever, and streptococcal infections accounted for 72 per cent of the bacterial infections and 31 per cent of infections due to all types of agents. With the exception of tularemia, these are all diseases in which the agents are extensively handled by many different types of laboratories. Although tuberculosis is listed as the second most common type of laboratory infection, it is recognized that the 153 cases reported constitute a very inaccurate estimate. One person reporting for a large institution stated that no attempt had been made to account for all the cases of tuberculosis which had developed among laboratory personnel, as it would be extremely difficult to trace the source. Not only was the reporting of tuberculosis very irregular, but in those cases which were reported it was seldom possible to say that these were more than probable or possible laboratory infections. As one of our correspondents stated, "How is one to evaluate the 16 hours a day which the laboratory worker spends outside of the laboratory?"

The species of *Brucella* involved was stated in about 60 per cent of the 224 cases of brucellosis. Abortus, melitensis, and suis strains were about equally involved. This distribution is somewhat different from that observed by Meyer and Eddie[1] who found 3, 35, and 62 per cent of laboratory infections due to these 3 species, respectively.

In each group of infectious agents there is one which considerably outnumbers the others as the cause of laboratory infections. Among the viral diseases there were nearly twice as many cases of hepatitis as of psittacosis, which is the second most common offender. Only 7 cases of hepatitis, however, could be classified as reasonably definite laboratory infections, while all but one of the cases of psittacosis appeared to have definitely originated in the laboratory. It is worthy of note that the great majority of cases of hepatitis reported have occurred in recent years.

Laboratory infections have occurred among the personnel of virtually all laboratories engaged in work with rickettsiae.[3] Among the rickettsial infections there are nearly twice as many cases of Q fever as of any other rickettsial diseases, although *C. burnetii,* the agent of Q fever, was recognized less than 14 years ago. In fact, the first known human infection with the agent of American Q fever occurred as a laboratory infection.[5] There are 4 cases of rickettsialpox even though this most recent addition to the Rickettsia group, *R. akari,* has only recently been recognized and is being studied in relatively few laboratories.

Amebiasis is first among the parasitic diseases, but here again it is difficult to say whether or not a given amebic infection originated in the laboratory. Coccidioides outnumbers all other fungi as a cause of laboratory infection, due undoubtedly to the highly infective nature of the chlamydospores. Laboratory infections with this agent are known to have occurred even in personnel who are

TABLE 1

Summary of Laboratory-Acquired Infections

Type of Infection	Disease or Agent	Number of Cases	Number of Cases Published	Infection Acquired in Laboratory: Definite	Probable	Possible	Outcome of Disease: Complete Recovery	Complications	Death
Bacterial	Brucellosis [a]	224(1) [b]	125	36	166	22	197	25	2
	Tuberculosis	153(1)	4	24 [c]	101	28	139	10	4
	Tularemia	65	22	40	20	5	63	1	1
	Typhoid	58(2)	6	28	23	7	54	0	4
	Streptococcal Infections	55	1	23	29	3	40	13	2
	Shigellosis	31	2	24	6	1	31	0	0
	Anthrax	30	25	29	1	0	29	0	1
	Erysipeloid	27	15	21	6	0	27	0	0
	Nonspecified Localized Infections	23	0	20	3	0	21	2	0
	Relapsing Fever	17	1	14	3	0	16	0	1 [d]
	Staphylococcal Infections	16(1)	0	12	1	3	15	0	1
	Diphtheria	15	0	13	0	2	15	0	0
	Rat Bite Fever [e]	11(1)	8	10	0	1	11	0	0
	Other Diseases [f]	50	20	46	4	0	46	1	3
	Sub-Total	775	229	340	363	72	704	52	19
Viral	Hepatitis	95(6)	27	7	69	19	93	1	1
	Psittacosis	44	15	43	1	0	39	3	2
	Lymphocytic Choriomeningitis	19	13	6	10	3	17	0	2
	Encephalitis [g]	17	12	17	0	0	15	0	2
	Yellow Fever	14 [h]	13	14	0	0	13	0	1
	Newcastle Disease Virus	11	3	4	4	3	11	0	0
	Rift Valley Fever	11	11	11	0	0	10	0	1 [i]
	Lymphogranuloma venereum	6	5	6	0	0	6	0	0
	Coxsackie Virus	6	6	6	0	0	6	0	0
	Poliomyelitis	4(1)	2	0	2	2	3	0	1
	Other Diseases [j]	38	23	28	4	5	36	0	2
	Sub-Total	265	130	142	91	32	249	4	12

	Q Fever	104	82	83	21	0	103	0	1
	Typhus (Endemic and Epidemic)	64	4	40	19	5	64	0	0
Rickettsial	Rocky Mountain Spotted Fever	16	1	8	8	0	15	0	1
	Scrub Typhus	12	9	5	7	0	8	0	4
	Rickettsialpox	4	2	4	0	0	4	0	0
	Sub-Total	200	98	140	55	5	194	0	6
	Amebiasis	18	1	0	11	7	18	0	0
Parasitic	Malaria	9	0	4	3	2	6	3	0
	Other Diseases [l]	12	1	4	4	4	10	0	0
	Sub-Total	39	2	8	18	13	36	3	0
	Coccidioidomycosis	49[k]	5	42	7	0	48	0	1
Fungus	Other Diseases [m]	14	3	8	1	5	13	0	1
	Sub-Total	63	8	50	8	5	61	0	2
	Total	1,342	467	680	535	127	1,244	59	39

[a] Forty-three of these infections were due to *B. abortus;* 42 to *B. melitensis;* and 52 to *B. suis.* The species responsible for the remaining infections was not indicated.

[b] Figure in parentheses indicates number of cases in which there was reason to question the diagnosis.

[c] Majority of these cases had cutaneous tuberculosis; source in most cases was autopsy.

[d] Cause of death acute pancreatitis; connection with laboratory infection not established.

[e] Five of these infections were due to *Streptobacillus moniliformis;* 2 to *Spirillum minus;* in 3 the agent was not indicated.

[f] Including salmonellosis, glanders, leptospirosis, meningococcal meningitis, *Treponema pallidum, Serratia marcescens,* gonococcus, septicemias (agent not indicated), tetanus, pneumococcal pneumonia, plague, *Pasteurella lepiseptica.*

[g] Three of these infections were due to the Western equine virus; one to the Eastern type; one to the Russian Far East Encephalitis virus; 11 to the Venezuelan equine virus; and in one the type was not indicated.

[h] Mouse-adapted neurotropic virus responsible for one of these infections.

[i] Patient died from pulmonary embolism following thrombophlebitis after convalescence seemed assured.

[j] Including vaccinia, primary atypical pneumonia, influenza, vesicular stomatitis, louping ill, B virus infection, measles, mumps, dengue, Colorado tick fever, viral diarrhea.

[k] Some of these were probably not overt infections but were recognized by the development of skin reactivity.

[l] Including ascariasis, strongyloidiasis, giardiasis, leishmaniasis, sarcosporidiosis, schistosomiasis, *Chilomastix mesnili,* hookworm, pinworm, leucocytozoon infection.

[m] Including ringworm, moniliasis, sporotrichosis, actinomycosis, blastomycosis.

TABLE 2

Personnel Acquiring Laboratory Infections

Type of Infection	Disease or Agent	Trained Scientific Personnel [a]	Students (Not Engaged in Research)	Animal Caretakers, Janitors, Dishwashers	Other Personnel (Clerical, Maintenance, etc.)	Not Indicated	Total
Bacterial	Brucellosis	146	11	35	32	0	224
	Tuberculosis	136	1	15	0	1	153
	Tularemia	62	0	2	0	1	65
	Typhoid Fever	38	13	5	2	0	58
	Streptococcal Infections	46	1	8	0	0	55
	Shigellosis	29	0	1	0	1	31
	Anthrax	16	0	8	6	0	30
	Erysipeloid	10	13	2	0	2	27
	Nonspecified Localized Infections	0	14	2	7	0	23
	Relapsing Fever	17	0	0	0	0	17
	Staphylococcal Infections	10	2	4	0	0	16
	Diphtheria	11	3	1	0	0	15
	Rat Bite Fever	5	3	2	0	1	11
	Other Diseases [b]	44	2	4	0	0	50
	Sub-Total	570	63	89	47	6	775
Viral	Hepatitis	79	0	13	0	3	95
	Psittacosis	23	0	3	0	18	44
	Lymphocytic Choriomeningitis	18	0	1	0	0	19
	Encephalitis	17	0	0	0	0	17
	Yellow Fever	13	0	1	0	0	14
	Newcastle Disease Virus	8	0	3	0	0	11
	Rift Valley Fever	11	0	0	0	0	11
	Lymphogranuloma venereum	6	0	0	0	0	6
	Coxsackie Virus	6	0	0	0	0	6
	Poliomyelitis	4	0	0	0	0	4
	Other Diseases [c]	33	0	2	0	3	38
	Sub-Total	218	0	23	0	24	265
Rickettsial	Q Fever	66	0	8	10[d]	20	104
	Typhus (Endemic and Epidemic)	54	0	4	5	1	64
	Rocky Mountain Spotted Fever	13	0	3	0	0	16
	Scrub Typhus	12	0	0	0	0	12
	Rickettsialpox	4	0	0	0	0	4
	Sub-Total	149	0	15	15	21	200
Parasitic	Amebiasis	17	0	1	0	0	18
	Malaria	8	0	0	1	0	9
	Other Diseases [e]	12	0	0	0	0	12
	Sub-Total	37	0	1	1	0	39
Fungus	Coccidioidomycosis	24	0	2	23	0	49
	Other Diseases [f]	12	0	2	0	0	14
	Sub-Total	36	0	4	23	0	63
	Total	1,010	63	132	86	51	1,342

[a] Including research assistants, professional and technical workers, and graduate students.
[b] See footnote f, Table 1.
[c] See footnote j, Table 1.
[d] Three of these infections occurred in laundry workers.
[e] See footnote l, Table 1.
[f] See footnote m, Table 1.

not working directly with the fungus.[6]

In Table 2 all the laboratory infections are classified according to type of personnel involved. The great majority of infections occurred among "Trained Scientific Personnel" which included professional and technical workers, research assistants, and graduate students. Further breakdown of this large category did not seem warranted because of the limited amount of information available. In many instances, for example, the individual was designated as "investigator" or "engaged in research." Furthermore, there may be a difference of opinion as to where the line, if any, is to be drawn between professional and technical workers. Graduate students are included here because their investigative work constitutes a different type of risk from that encountered by students whose only contact with infectious agents is in connection with classwork. The category of "students" has therefore been reserved for those not engaged in research, i.e., undergraduate students or medical or veterinary students performing class exercises. Another category consists of non-technical personnel including animal caretakers, janitors, and dishwashers. Still another includes persons who are not directly associated with work involving infectious agents, such as clerical and maintenance workers, as well as occasional visitors who apparently have acquired infections in the laboratory. In 51 of the 1,342 cases there was insufficient information available to classify the individual in any of the 4 categories mentioned.

It is regrettable that there is insufficient information regarding the number of persons exposed to the risk of infection in each of these categories to establish the incidence of infection. Seventy-five per cent of all infections occurred among trained, scientific personnel, this being, of course, the group which is exposed to the greatest risk. The number of students who are in contact with infectious agents in classwork must be extremely large, yet only 63 instances of infection were reported in this group. All of these infections in students were due to bacteria. If one eliminates the cases of erysipeloid, most of which occurred in veterinary students as a result of contact with turkeys or horse cadavers, the hazards of handling infectious agents by students in classwork do not seem to be great. Thirteen of the 95 cases of hepatitis occurred in dishwashers, a fact which is significant in connection with the recognized danger of hepatitis in this type of personnel.[7]

Laboratory-acquired infections, classified according to the type of work responsible for the infection, are summarized in Table 3. The four main types of work in which infectious agents are handled are research, laboratory diagnosis, production of biologics, and classwork. Partly because of deficiencies in our information and partly for reasons inherent in these kinds of activities, it was frequently impossible to place an in-

TABLE 3

Number of Laboratory Infections Resulting from Various Types of Work

Type of Infection	Research	Diagnostic	Production of Biologics	Classwork	Classwork and/or Research	Research and/or Diagnostic	Research and/or Biologic Production	Total
Bacterial	132	333	5	29	41	203	32	775
Viral	81	86	20	0	0	65	13	265
Rickettsial	67	3	0	0	0	125	5	200
Parasitic	17	16	0	0	0	6	0	39
Fungus	11	17	0	0	0	35	0	63
Total	308	455	25	29	41	434	50	1,342
Per cent of Total	22.9	33.9	1.9	2.2	3.1	32.3	3.7	

TABLE 4

Distribution of Cases According to Proved or Probable Source of Infection

Type of Infection	Accidents [a]	Contact with Infected Animals and Ecto-parasites	Aerogenic	Clinical Specimens	Worked with Agent	Autopsy (including known accidents)	Handled Dis-carded Glass-ware, etc.	Not Indicated	Total
Bacterial	153	82	23 [d]	83	164 [b]	92 [c]	15	163	775
Viral	30	27	25	75	67	6	0	35	265
Rickettsial	15	25	89 [f]	0	27	0	4 [e]	40	200
Parasitic	9	5	1	17	6	0	0	1	39
Fungus	8	0	35	0	10	0	1	9	63
Total	215	139	173	175	274	98	20	248	1,342
Per cent of Total	16.0	10.3	12.9	13.0	20.4	7.3	1.5	18.5	

[a] Not including known autopsy accidents.
[b] One case of tuberculosis and one of brucellosis resulted from intentional self-inoculation.
[c] Ten of 57 cases of tuberculosis in this category were nonpulmonary infections.
[d] A fatal case of typhoid fever resulted from opening lyophilized cultures.
[e] Three of these are cases of Q fever which resulted from handling laundry contaminated in the laboratory.
[f] Two cases of typhus and one of rickettsialpox apparently resulted from the use of the Waring Blendor.

dividual case in one of these specific categories. Most teaching institutions dealing with pathogenic microörganisms also maintain research programs. In other instances, such as work with the virus of psittacosis, research and diagnostic procedures are carried out in the same laboratory. Similarly, it was frequently impossible to draw a line between research and the production of biologics. Consequently, rather than list some 40 per cent of the infections as unknown with regard to the type of work performed, it seemed advisable to set up the 3 additional categories indicated in the table. The greatest number of infections occurred in persons engaged in diagnostic work. This, of course, does not necessarily mean that the carrying out of diagnostic procedures involves greater risk than investigative work because doubtless more individuals are involved in the former type of activity. The 25 laboratory infections associated with the production of biologics, which have come to our attention, probably represent only a small proportion of those which have occurred.

As has been pointed out in the analysis of Table 2, the infections traceable to classwork are confined to the bacterial diseases, since the use of other agents under these circumstances is extremely limited. Of the 29 infections resulting from classwork, 13 were typhoid fever. The 80 cases of viral hepatitis listed as resulting from diagnostic work originated mostly from specimens of blood submitted for serological or chemical examinations rather than for diagnostic work in virology. Trumbull and Greiner [8] present further evidence emphasizing the importance of hepatitis as an occupational hazard to medical personnel. In connection with the occurrence of hepatitis among persons engaged in the processing of blood, Kuh and Ward [9] point out that the handling of dried plasma or dried blood derivates involves no greater hazard than the handling of whole blood.

If one excludes the cases of hepatitis, research was much more likely to be the cause of laboratory-acquired viral infection than were diagnostic procedures. In a large proportion of the viral and rickettsial infections, it was not possible to separate research from diagnosis. This situation undoubtedly arises from the fact that diagnostic procedures involving these agents are not likely to be undertaken, except in a research laboratory.

In Table 4 the cases are classified ac-

TABLE 5

Number of Laboratory Infections Resulting from Various Types of Accidents

Type of Infection	Accident Involving Needle and Syringe	Spilling and Spattering of Viable Organisms	Injury with Broken Glass, etc.	Pipetting	Bite of Animal or Ectoparasite	Accident Involving Centrifuge	Not Indicated	Total
Bacterial	40	28	29	29	18	2	7	153
Viral	8	11 [a, b]	3	4	2	2	0	30
Rickettsial	6	3 [b]	1	0	5	0	0	15
Parasitic	1	2	0	0	6	0	0	9
Fungus	2	2	1	0	1	2	0	8
Total	57	46	34	33	32	6	7	215
Per cent of Total	26.5	21.4	16.0	15.4	14.9	2.8	3.3	

[a] Two psittacosis infections resulted from handling broken vials of lyophilized virus.
[b] Three infections with psittacosis virus and one with typhus rickettsia were due to accidents with Waring Blendors.

cording to the proved or probable source of the infection. Each infection is indicated under only one source, although more than one heading might be applicable in individual cases. Because of the importance of determining the frequency of known accidents, any accidental infection was so classified even though, for example, a clinical specimen might have been involved. Accidents in the laboratory accounted for 215 or 16 per cent of all infections. These accidents are analyzed more completely in Table 5. The heading "Aerogenic" was reserved for those cases in which this source appeared to be the most likely, even though the actual mode of transmission in many of those infections which resulted from work with the agent may well have been aerogenic. It seemed advisable to separate those infections resulting from autopsies on human bodies from the others, because it might be argued that these are not truly laboratory infections. Consequently, accidents which occurred in connection with autopsy procedures were classified under "Autopsy" rather than as accidents. In a considerable proportion of the infections, the source was not indicated and presumably was not known. In the greatest number of cases the source could be designated only as "Worked with Agent."

Contact with infected animals and ectoparasites was responsible for many more infections than was the handling of discarded glassware and other apparatus. With many of the infectious agents the predominating source of infection could probably have been predicted on the basis of our general knowledge of the disease. In tuberculosis, with the exception of autopsy infections, the greatest number was derived from clinical specimens. A relatively high proportion of cases of typhoid fever and streptococcal infections resulted from accidents. The majority of cases of hepatitis resulted from handling clinical specimens, particularly blood specimens. In Q fever only one case was attributable to an accident, while the majority of infections was thought to be aerogenic. A similar situation exists in coccidioidomycosis.

Two cases, one of brucellosis and one of tuberculosis, were the result of intentional self-inoculations. These have been included as laboratory infections because the individuals involved would not have resorted to this procedure had they not been laboratory workers.

Although the Waring Blendor is widely used for disrupting infected tissues, only three infections, two of typhus and one of rickettsialpox, were attributable to the use of this apparatus in the absence of known accidents. Many persons, however, working with highly infectious material use containers specially designed to minimize the creation of hazardous aerosols frequently resulting from the use of the Waring Blendor.

Only three cases were indicated as being caused by a break in discipline or a failure to follow instructions. Two cases of typhoid followed the use of unplugged pipettes which was contrary to instruction. One case of meningococcal meningitis resulted when a student obtained a culture from outside sources and brought it to the laboratory as a joke.

When the laboratory infections due to known accidents were classified according to the headings used in Table 5, it was found that certain types of accidents tend to occur repeatedly. There was no accident, the nature of which was indicated, which could not readily be placed in one of these categories. The type of accident responsible for the largest number of infections was associated with the use of a hypodermic needle and syringe. The most common accidents of this type were: 1. accidental self-inoculation with the needle, and 2. spattering of infectious material when the needle became loose from the syringe. Some of these accidents resulted when the animal being inoculated was not held securely. Pipetting, animal or ectoparasite bites, injuries with broken glass and other objects, and spilling and spattering of viable organisms were about equally involved in accidental infection. Eleven of the 17 cases of typhoid fever following known accidents resulted from the aspiration of infectious material through pipettes. The highest proportion of infections resulting from bites is seen in the rickettsial diseases where cases of typhus, Rocky Mountain spotted fever and scrub typhus resulted from the bites of ectoparasites. It is interesting to note that no case of dog bite resulting in rabies or in any other type of infection has come to our attention as occurring in the laboratory. In this connection, work involving the use of street virus in guinea pigs has not been considered a sufficient risk to warrant vaccination of personnel.[10] Undoubtedly there have been many minor infections resulting from injuries from broken glass and other material which have not been reported to us. Some replies to the questionnaire stated that no attempt had been made to list such infections. It is perhaps surprising that only one case of septicemia resulting from this type of accident has been reported.

Spilling and spattering of viable organisms included such accidents as dropping flasks containing cultures, spilling the contents of culture tubes, spattering associated with opening vials containing lyophilized material, spattering infected fluid in connection with opening embryonated eggs and a few other less common accidents. The number of accidents directly attributable to the use of chick embryos is not large, although workers have been cautioned about the dangers inherent in this type of work. Some of these types of accidents are obviously preventable. Others cannot be anticipated and can be reduced only by exercising general precautions.

An interesting point which is not brought out by the data presented in the tables is that a number of individuals have acquired more than one laboratory infection. For example, one individual, at different times during his laboratory experience, contracted relapsing fever, dengue fever, tularemia, brucellosis and psittacosis. The last three of these are frequent laboratory infections as indicated in the tabulated results. Colorado tick fever, rift valley fever, and yellow fever all occurred in one individual, while dengue fever, psittacosis and lymphocytic choriomeningitis occurred in another. Still another individual suffered from tuberculosis and brucellosis at the same time, both infections being acquired in the laboratory. Although the pneumococcus has not often been responsible for laboratory infections, one individual had two episodes of pneumococcal pneumonia, one of which was due to Type 1 and the other to Type 2.[11]

Accidents with potentially infectious material do not necessarily result in infection. One laboratory worker drew a suspension of living typhoid bacilli into her mouth but suffered no illness. Another person accidentally introduced into his skin a needle attached to a syringe containing *Treponema pallidum*. No visible infection resulted, and serologic tests for syphilis remained negative. The introduction of live brucella organisms into the mouth in one individual and tuberculous sputum in another failed to cause recognizable disease. Both of these individuals, however, evidently had inapparent infections, because the one developed brucella agglutinins while the other became tuberculin-positive.

Although numerous inapparent infections have been reported to us, these have not been included in the tabulation, except in the case of coccidioidomycosis. In this disease it is not always possible to determine from the available information whether or not an overt infection has occurred.* A previous communication [2] called attention to inapparent infections with the equine encephalomyelitis viruses, lymphocytic choriomeningitis virus and others. Numerous persons working with, or in proximity to, *Coccidioides imitis* experienced inapparent infections as indicated by the development of positive skin reactions to coccidioidin.[6] Inapparent infections have resulted from laboratory work with the agents of brucellosis, tularemia, Q fever, lymphogranuloma venereum, and numerous others.

The development of bacterial hypersensitivity may constitute a real laboratory hazard under some circumstances. One of our correspondents reported 7 instances of the development of hypersensitivity to *Brucella*, which occurred during the course of the preparation of antigens using the Sharples centrifuge. The sensitivity in these individuals became so marked that they could no longer engage in this type of work. Several persons have referred to the development of tuberculin hypersensitivity in persons associated with the production of tuberculin. It has been stated that anyone planning to work in such a laboratory should have a negative tuberculin test and a negative x-ray.

Prophylactic immunization is available against many of the agents that have been responsible for laboratory infections. Such immunization with the typhoid bacillus [12] and with certain rickettsiae [4] does not necessarily prevent infection, but those infections which have been observed in immunized persons tend to be less serious. On the other hand, to our knowledge, no cases of laboratory-acquired yellow fever have occurred since the introduction of inoculation. Also, it has been suggested that the use of the lyophile process for drying of infectious material may have contributed to the eradication of this danger. Immunization with psittacosis virus vaccine has been suggested [13, 14] but the effectiveness of this procedure has not been definitely demonstrated.

Immunization is recommended for those individuals anticipating work with the equine encephalomyelitis viruses.[15] No vaccine is available for lymphocytic choriomeningitis but it has been recommended that only those known to have a significant titer of antibodies be permitted to work with the virus. Convincing evidence of the efficacy of vaccine prophylaxis in tularemia in laboratory workers has been reported by Foshay.[16] Although not preventing infection following accidental inoculation, immunization apparently prevented systemic infection. Although many cases of ocular infection with vaccinia usually associated

* There is also evidence to indicate that a similar situation exists in histoplasmosis.

with vaccination have been reported, this infection rarely occurs as a laboratory accident because of the effectiveness of inoculation. Three of the cases which have been reported to us occurred in persons handling large amounts of highly concentrated rabbit-adapted virus.[17]

The highly effective chemotherapeutic agents now available for many infections which have been contracted in the laboratory had not been introduced when many of the infections recorded here occurred. For brucellosis, tularemia, typhoid fever, streptococcal infection, psittacosis, Q fever, typhus, and many others the existence of effective antibiotics should help to eliminate the anxiety which some individuals may experience in connection with working with these agents.[18]

SUMMARY

A total of 1,342 infections, presumably acquired as a result of laboratory work in the United States, have been tabulated. Death resulted in 39 instances, a case fatality rate of 3.0 per cent. Approximately one-third of the infections have been recorded in the literature; the remainder were discovered by means of a questionnaire mailed to nearly 5,000 laboratories.

The laboratory-acquired infections include 775 bacterial, 265 viral, 200 rickettsial, 39 parasitic, and 63 due to fungi. At least 69 different agents were involved but brucellosis, tuberculosis, tularemia, typhoid fever and streptococcal infections accounted for 72 per cent of the bacterial infections and 31 per cent of all infections. The species of *Brucella* involved was stated in about 60 per cent of the 224 cases of brucellosis. *B. abortus, B. melitensis,* and *B. suis* were about equally involved. Coccidioides outnumbers all other fungi as a cause of laboratory infection, due undoubtedly to the highly infective nature of the chlamydospores. Laboratory infections with this agent are known to have occurred even in personnel who are not working directly with the fungus.

Trained scientific personnel were involved in 1,015 of the infections; the remainder occurred in students, animal caretakers, janitors, and others. Research accounted for 308 cases, diagnostic work for 455, production of biologics for 25, and classwork for 29, while in the remaining cases a combination of activities was involved.

The probable source of infection was indicated in all except 248 cases. The handling of clinical specimens and infected animals or ectoparasites accounted for 175 and 139 cases, respectively. Aerogenic transmission and "work with the agent" were other frequently recognized sources of laboratory infection. There were 98 infections acquired in the autopsy room. Recognized accidents, excluding autopsy accidents, were involved in 215 instances. The type of accident responsible for the largest number of infections was associated with the use of a hypodermic needle and syringe.

An interesting point which is not brought out by the data presented in the tables is that a number of individuals have acquired more than one laboratory infection. Also, although numerous inapparent infections have been reported to us, these have not been included in the tabulations.

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Polio Conference in Copenhagen

The Second International Poliomyelitis Conference will be held in Copenhagen, September 3–7, 1951, sponsored by the National Foundation for Infantile Paralysis of the United States and by the Danish National Association for Infantile Paralysis. The conference will be held at Medicinsk-Anatomisk Institut of the University of Copenhagen. The Danish Medical Association will share with the university in being hosts to this international conference.

Rustin McIntosh, M.D., professor of pediatrics, Columbia University College of Physicians and Surgeons, is chairman of the Advisory Committee; Dr. H. C. A. Lassen of Denmark is chairman of the Executive Committee and secretary-general of the conference.

The American Public Health Association is one of a number of organizations endorsing the conference.